

**REMARKS**

Applicants respectfully request further examination and reconsideration in view of the above amendments and arguments set forth fully below. Claims 1-47 were previously pending in the this application. Within the Office Action, Claims 1-47 have been rejected. By way of the above amendments Claims 1, 2, 4-10, 15-23, 26-32, 35, 39-43 and 45-47 have been amended, Claims 3, 11-14, 24, 25, 33, 34, 36-38 and 44 have been canceled and new Claims 48-51 have been added. Accordingly, Claims 1, 2, 3-10, 15-23, 26-32, 35, 39-43 and 45-51 are now pending in this application.

**Objection to Specification:**

The Specification has been objected to for a number of informalities. Included along with this response is a Substitute Specification in compliance with 37 C.F.R. § 1.121(b)(3) and a marked-up copy of the Substitute Specification showing the changes made, in accordance with 37 C.F.R. § 1.125.

The substitute Specification includes conventional formatting and sub-sections and a Related Applications sub-section has been added. No new subject matter has been added by way of this amendment.

**Objection to Claims:**

Within the Office Action Claims 1-47 have been objected to for a number of informalities. Claims 1, 2, 4-10, 15-23, 26-32, 35, 39-43 and 45-47 have been amended and Claim 3, 11-14, 24, 25, 33, 34, 36-38 and 44 have been canceled to address these informalities.

**Rejections Under 35 U.S.C. § 102(b)**

Within the Office Action, Claims 1-5, 7-8, 11, 15-17, 27, 32 and 39-47 have been rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,323,468 to Bottesch (hereafter "Bottesch"). The rejection of Claims 1-5, 7-8 11, 15-17, 27 and 39-47 under 35 U.S.C. § 102(b) as being anticipated by Bottesch are considered to be moot in view of the above amendments.

Applicants contend that a device for producing high quality, high fidelity sound, and especially music, in an aquatic environment is neither taught nor suggested in the prior art. In

particular, Bottesch fails to teach or suggest features of bone conduction audio system that is either suitable nor optimized for use in an aquatic environment.

Proper fitting and placement of transducers on a user's head is complicated. There are great inter-subject differences found with respect to the transcranial attenuation of vibrations generated between the mastoid processes. Thus, the vibrations of the human skull differs depending on skull shape and skull density. Variations in bone conduction quality can occur due to differences in the amount of soft tissue interposed between the vibrator and skull. Thus, the contact area of the transducer influences the transmission efficiency through the skin. Larger contact areas have better transmission properties.

For some, mastoid location may not be optimal location for bone conducted sound. For instance, at low frequencies of approximately 200 Hz when stimulating at the forehead, the skull conducts vibrations as a rigid body. At 800 Hz, the forehead and occiput vibrate in opposite phase. At 1600 Hz, the two temporal regions vibrate in opposite phase, and the head and neck regions also vibrate with opposite phases. Further, the activity (e.g., swimming) may make the mastoid location less than optimal. To accommodate for a user's specific cranial anatomy and to optimize sound quality, an audio system suitable for use in, for example, an aquatic environment preferably includes transducers that can be repositioned to alternative locations on the user's head. The system of Bottesch has a set of transducers that are attached to a "cage" structure, which holds the transducers in a single fixed configuration on the user's head.

In contrast to the audio system of Bottesch, the present invention preferably includes transducers that are movably coupled to a support structure, such as a head band, goggles, hat, helmet, etc. (see Figures 7-9 of the application and page 12 of the application) wherein the transducers are can be moved to and secured to multiple locations along the support structure. These features are now recited in each of the independent Claims 1 and 32. As described above, Bottesch fails to teach or suggest the transducers and a support structure that allows for repositioning of the transducers. For at least these reasons, the independent Claims 1 and 32 are allowable over the teachings Bottesch.

Transmission of the high quality audio output through bone conduction in an aquatic environment is facilitated by having transducers that fit firmly against the bony portions of a user head and that are waterproof. Accordingly, an audio system of the present invention preferably includes transducers that are housed in a waterproof polymeric material. The waterproof polymeric material helps the transducers fit to bony portions of the user's head and transmission fidelity of the audio output from the transducers to the user's head. As described above, Bottesch

fails to teach or suggest transducers that are housed or partially housed in a polymer waterproofing material. These features are now recited in each of the independent Claims 32 and 40. For at least these reasons, the independent Claims 32 and 40 are now both allowable over the teaching of Bottesch.

5           By way of the above amendment, Claims 3, 11 and 44 have been canceled. Claims 2, 4, 5, 7-8, 15-17 and 27 are all dependent on the independent Claim 1; Claim 39 is dependent on the independent Claim 32; and Claims 41-43 and 45-47 are all dependent on the independent Claim 40. As described above, the independent Claims 1, 32 and 40 are all is allowable over the teachings of Bottesch. Accordingly, Claims 2, 4, 5, 7-8, 15-17, 27, 39 and 41-43 and 45-47 are  
10 also all allowable as being dependent on allowable base claims.

**Rejections Under 35 U.S.C. § 103(a)**

Within the Office Action, Claims 6, 9, 10, 12-14, 18-26, 28-31, 38 and 40-47 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Bottesch. The rejection of Claims  
15 6, 9, 10, 12-14, 18-26, 28-31, 38 and 40-47 under 35 U.S.C. § 103(a) as being unpatentable over Bottesch are considered moot in view of the above amendments.

Claims 12-14, 24, 25, 38 and 44 have been canceled. For all the reasons described above, each of the independent Claims 1, 32 and 40 are now allowable over the teaching of Bottesch. Claims 6, 9, 10, 18-24, 26 and 28-31 are all dependent on the independent Claim 1; Claim 38 is  
20 dependent on the independent Claim 32; and Claim 41-43 and 45-47 are all dependent on the independent Claim 40. Accordingly, Claims 6, 9, 10, 18-24, 26, 28-3, 38, 41-43 and 45-47 are all also allowable as being dependent upon allowable base Claims.

**New Claims:**

25           In an aquatic environment, an ear canal is typically filled with water. This results in a person's frequency response, or perceived frequency response, to change and audio sounds can become "hollow." This hollowing effect of audio output is referred to as an occlusion effect.

The occlusion effect is not suggested by the teachings of Bottesch. In fact, Bottesch specifically teaches the preservation of air-conducted sound. As Bottesch teaches, bone  
30 conducted sound can be used with an open ear canal. However, bone conducted sound is less efficient than air conducted sound. Skin contact attenuates high frequency sound and low transcranial attenuation makes stereophonic sound more difficult.

The occlusion effect is demonstrated through the conducted low-frequency emphasis of one's own voice when ear canal openings are occluded. The occlusion effect changes the resonance properties of the ear canal that differ from those of an open tube. Occlusion of the external ear canal increases the sound pressure approximately 20 dB for frequencies below 1000 Hz. Thus, it is only when the ear canal is occluded that bone conducted hearing is dominant for frequencies below 1000 Hz.

To address the problems of the occlusion effect, the audio system of the present invention preferably includes multiple transducers with multiple frequency responses or channels. Preferably, the frequency channels have independent output controls, such that the audio system can be "tuned" and occlusion effect can be significantly reduced. The features of multiple transducers with multiple frequency responses, wherein the frequency responses are independently controllable, such as recited in the new independent Claim 48 are neither taught nor suggested by the teachings of Bottesch. For at least these reasons, the new independent Claim 48 is allowable over the teaching of Bottesch.

The Claims 49 and 50 are both dependent on the independent Claim 48. As described above, the independent Claim 48 is allowable over the teaching Bottesch. Accordingly, Claims 49 and 50 are also both allowable as being dependent upon an allowable base Claim.

Claim 51 is directed to the embodiment shown in Figure 9 of the application, and is allowable as being dependent on allowable base Claim. In addition, claim 51 specifically references swim goggles which are not shown or suggested by Bottesch and Bottesch could not be adapted to work with swim goggles.

For the reasons given above, Applicants respectfully submit that Claims 1, 2, 3-10, 15-23, 26-32, 35, 39-43 and 45-51 are now in a condition for allowance, and allowance at an early date would be appreciated. Should the Examiner have any questions or comments, the Examiner is encouraged to call the undersigned at (408) 530-9700 to discuss the same so that any outstanding issues can be expeditiously resolved.

Respectfully submitted,  
HAVERSTOCK & OWENS LLP

Dated: November 24, 2006

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**CERTIFICATE OF MAILING (37 CFR § 1.8(a))**  
I hereby certify that this paper (along with any referred to as being attached or enclosed) is being deposited with the U.S. Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to the: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450

- 13 -

HAVERSTOCK & OWENS LLP

Date: 11/24/06 By: [Signature]



# RECREATIONAL BONE CONDUCTION AUDIO DEVICE, SYSTEM

## DESCRIPTION

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### ~~BACKGROUND OF THE INVENTION~~

#### RELATED APPLICATION

This Patent Application claims priority under 35 U.S.C. 119 (e) of the co-pending U.S. Provisional Patent Application Serial No. 60/399,699, filed August 1, 2002, and titled "RECREATIONAL BONE CONDUCTION AUDIO DEVICE, SYSTEM." The co-pending U.S. Provisional Patent Application Serial No. 60/399,699, filed August 1, 2002, and titled "RECREATIONAL BONE CONDUCTION AUDIO DEVICE, SYSTEM" is also hereby incorporated by reference.

#### *Field of the Invention*

#### 15 FIELD OF THE INVENTION

The present invention generally relates to waterproof recreational audio devices and, more particularly, to recreational audio devices that provide high quality musical sound to users through bone conduction sound transmission and the methods related thereto.

20

#### *Background Description*

#### BACKGROUND

Since the introduction of the Sony Walkman in July of 1979, over 100 million units have been sold. The Oxford English Dictionary certified 'walkman' as a noun in 1986 describing it as a personal audio device. The

recreational audio device has established itself as a mainstay for personal music enjoyment. Advances in the personal audio device market have typically been focused in two areas: size of the unit and headphone improvements. Headphones for personal audio systems have historically  
5 been air conduction systems that rely on tympanic hearing for sound transmission.

In tympanic hearing, sound travels through the ear canal to the eardrum making it vibrate. These vibrations are passed to three small bones in the middle ear, the ossicles, by a process called air conduction.  
10 These in turn pass the vibrations to the cochlea and the fluid it contains. Movement in this fluid bends the tiny hair cells along the length of the cochlea, generating signals in the auditory nerve. The nerve signals pass to the brain, which interprets them as sound. Bone conduction hearing is when sound vibrations are transmitted directly from the skull and jaw  
15 bones to the cochlea, missing the outer and middle ears. Air conduction sound systems provide stereo quality sound by taking advantage of the ability of the human brain to take in sound from the two ears and integrating the multiple sound sources into a single, richer sound. While bone conduction devices have traditionally been developed for the hearing  
20 impaired and as hearing aid devices until recently, these devices focused on transmitting sound in the speaking voice frequency range and have not been adapted for high fidelity musical signals. Additionally, the recreational audio systems for the underwater environment have traditionally relied on air conduction with ear plugs for the sound  
25 transmission.

While small, streamline systems exist for land based recreational audio, they are predominately of the air conduction type. Several of these systems have been waterproofed for use by swimmers. These systems rely on ear plugs that are placed in the ear such that an air bubble is formed in  
30 the ear canal. When this bubble is intact, the sound transmission is

acceptable. However, the ear canal acoustic resonance is lost if it fills with water while the head is submerged. With bone conduction sound transmission, this disadvantage is overcome. Specifically, when the ear canal is filled with water, as when a swimmer is submerged, the mass of the water (4.5 times denser than air) acoustically loads the ear drum enhancing low frequency sound reception in the ear to bone conduction [Tonndorf, J. A New Concept of Bone Conduction, *Arch Otol* 87, 49 - 54 1968].

Common bone conduction type devices have been developed to transmit sound in the speech frequency range and have not been maximized to provide musical sound quality. In addition, bone conduction devices have been either large units that were heavy, bulky and uncomfortable for the user or have been devices integrated into a bite plate for sound transmission via the jaw bone (May US Patent 5,579,284). Bit plate type of sound transmission actually requires the user to continually bite down on the device in order to hear the sound.

An audio systems using bone conduction is shown in U.S. Patent 4,791,673 to Schreiber. This invention is an audio listening system that includes both a bone conduction device and a sound source unit. The system has a transducer mounted in a c-shaped element that hooks around the ear of the user. A suction cup element is included as part of the transducer feature to ensure contact from the transducer to the mastoid region behind the ear of the user. This device is water resistant but not waterproof and has only one type of transducer to transmit sound to the user.

A further device is shown in U.S. Patent 5,323,468 to Bottesch that provides a means for the conduction of sound waves through the mastoid bones of the user and selectively amplifying predetermined frequency ranges that the invention claims do not conduct well through the bone so as to maximize the transmission of all signals in the sound source frequency

range. The invention is a small, light weight head gear that puts one or several transducers in contact with the mastoid region of the skull. The headgear is designed to provide stereophonic music to the user by transmitting the stereo sound signals separately to transducers located  
5 behind the ear of the user. This device is not waterproof and only provides one type of transducer for transmitting across the multiple frequency ranges.

A third bone conduction device is shown in U.S. Patent 5,889,730 to May that provides an underwater audio communication system for  
10 transmitting voice through bone conduction at the mastoid region of the head. This device is designed to allow voice communication to and from an underwater user. The device mounts one or more of the same type transducers onto the users scuba face mask. A transceiver and amplifier is located on the back of the users head to transmit and receive ultrasonic  
15 sound signals for communication with the user.

## **~~SUMMARY OF THE INVENTION~~**

### **SUMMARY**

It is therefore an object of the present invention to provide a  
20 waterproof recreational audio device to allow a listener to hear high fidelity musical signals through transcutaneous bone conduction.

A further object of the invention is to provide high fidelity sound by maximizing the quality of the sound transmission across the three frequency ranges of musical sound.

25 Another object of the present invention is to provide an integrated recreational audio system that includes both the headphone unit and the signal source unit.

Additionally, an object of the present invention is to enable the user to position the device on the head for tuning of the sound for the user.

30 The waterproof recreational audio device of the present invention



has an enhanced frequency range over that of previous devices so as to overcome the limited sound quality of existing bone conduction systems. In addition, the present invention is integrated into a light weight headgear that is more comfortable than previous hearing aid type units to enable the individual user to adjust the headgear for personal preferences. The waterproof recreational audio device is also constructed to enable high quality musical signals to be 'heard' while in an underwater environment. However, the intended environment should not be construed as limiting the device to this use. Athletic users may appreciate the light weight, waterproof and streamline configuration of the invention while engaging in other athletic activities such as running, biking, hiking, etc.

According to the present invention, the foregoing and other objects are achieved in part by having a transducer in contact with the skull of the user for transmitting musical signals via bone conduction. The musical signals differ from ordinary speech in that the average frequency range for normal speech is approximately 120 Hz to 8,000 Hz, while high fidelity musical signals can range from 20 Hz to over 20, 000 Hz. This range can be extended even further to meet the newer digital sampling technology with high frequencies of almost 40,000 Hz.

The present invention has at least one transducer that is able to transmit transcutaneous sound via bone conduction through the head of the user. The present invention is functional with at least one transducer, however, at least one transducer should also be understood to include a plurality of transducers. An amplifier can also be worn on the head of the user or can be part of a signal source unit to which the transducer or transducers are connected. The present invention is intended to be worn on the head of the user. The transducer may be fixed to a band that encircles the head of the user or other head gear such as hats, helmets, headbands, or eye wear such as goggles, face mask or sun glasses.

The musical frequency range is split into three distinct channels by

the present invention. That is: low frequency from 0 Hz to 1000 Hz, mid frequency from 25 Hz to 6,000 Hz and high frequency from 5,000 to over 20,000 Hz. With new digital sampling device, the upper end frequency range can extend to as high about 40,000Hz. The present invention can

5 use commercially available transducers coupled with the amplifier to produce sound in the mid frequency range. The low frequency response is achieved by applying very low frequencies to the head using a vibrotactile transducer. To provide the high frequency musical signal to the user, the present invention can also include an ultrasonic transducer. The ultrasonic

10 transducer may be of a piezoelectric type or similar. Each channel requires special amplification provided by the invention. The low frequency has low impedance whereas the high frequency device has about 10 times the impedance. Thus, the three channel amplifier is designed to three different impedances. In addition, each of these frequency channels can have their

15 own volume adjustment. The upper end of the volume can be preset to reduce potential damage to the listener. The preset volume can also be limited specifically for the mid frequency range to allow the user to hear external environmental sound and to provide a volume limit such that others in close proximity to the user do not hear the sound signal from the

20 present invention if the device is worn other than underwater.

Perceptually, bone conduction using the three channels of sound, results in a high fidelity sound quality for the purpose of music listening. The three channels, when listened to underwater, permit a flexible sound quality that allows changes in the sound envelope appropriate for musical

25 articulation. The low frequency range channel proposed is conducive to low and high pitch sounds that enhance the appreciation of both human voice and instrumental applications for music. With air conduction minimized by water or earplug, the proposed device also offers unique clarity with minimal distortion. Further, the impediment of air conduction,

30 through water or earplug, with this device also reduces noise that can

hamper music appreciation. The sound quality from the three channel device with its three transducers is omnidirectional when heard underwater. With ear masking as described, it has a timbre that is comparable to high fidelity instrumentation with above-surface stereophonic attributes.

The waterproof recreational audio device can also enhance the music signal by enabling tuning of the device to the individual users preference through positioning of the transducers on the users head. The human skull is very asymmetrical with regard to its vibratory response. In addition, there are idiosyncratic vibratory differences due to individual specific skull geometries [Cai, Z., Richards, D. G., Lenhardt, M.L. and Madsen, A.G., Response of the Human Skull to Bone Conducted Sound in the Audiometric to Ultrasonic Range., *International Tinnitus Journal*, 8, 1, 1 - 8, 2002]. The transducers of the device can be placed in a standard position (i.e., over the ear in the mastoid region and on the forehead in the frontal region, etc.). However, the sound quality may not be considered optimum for some users. To compensate for the acoustics in skull geometry, the transducers can be placed on the head band 180° apart, or at another desired orientation, allowing the user to rotate the band around the head to select the position of best music reception. This can be readjusted underwater due to the different acoustic properties of that medium and its interaction with the head. In a second embodiment, each transducer may be moveable about the head band independently, until the best sound reception is achieved. This allows custom tuning for each frequency band resulting in the greatest user satisfaction.

As a waterproof recreational audio device, the present invention has a further embodiment that integrates the sound source with the sound transmission. This sound source can be in the form of a disk player (e.g., CDs, DVDs, minidiscs, etc.), MP3 player, AM/FM radio, audio transceiver or other such devices known as personal audio devices. The sound source

can communicate with the transducers by wireless or wired connection.

Finally, the objects are met by providing the functional elements and a method for positioning the transducers at various locations on the head of the user. The transducers may be fixed to the band or other head gear and the head gear would be rotated around the head. In addition, the transducers may be able to slide to different locations around the head gear. Finally, the transducers may be able to be removed from the head gear and then to be replaced in another location around the head gear. As a minimum, the user should be able to locate transducer at the front and the back of the head. By moving the transducers, the user may improve both perceived personal sound quality and personal comfort for wearing the device.

### **~~BRIEF DESCRIPTION OF THE DRAWINGS~~**

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The foregoing and other objects, aspects and advantages will be better understood from the following detailed description of a preferred embodiment of the invention with reference to the drawings, in which:

Figure 1 shows a user wearing the waterproof recreational audio device, system as a head band.

Figure 2 shows one or several transducers located within the headband.

Figures 3a shows the means of connecting and moving the transducers relative to the user and the head band by sliding the transducers along a guide on the head band.

Figure 3b show the means of connecting and moving the transducers relative to the user and the head band using hooks or snaps.

Figure 3c show the means of connecting and moving the transducers relative to the user and the head band using Velcro.

Figure 4 shows a simple block diagram for amplifier unit.

Figure 5a shows the components of the high frequency transducer.

Figure 5b shows one embodiment of waterproofing on a cross section of a transducer with the head band.

Figure 6a shows a wired connection to a sound source.

5 Figure 6b shows a wireless connection to a sound source.

Figure 7 shows a configuration of the device attached to a hat.

Figure 8 shows a configuration of the device attached to a helmet.

Figure 9 shows a configuration of the device attached to swim goggles.

10 Figure 10 shows another embodiment with a transducer located on the frontal region of the head and a stabilizing strap across the top of the user's head.

### ~~DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION~~

#### 15 DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, and more particularly to Figure 1, the preferred embodiment of the waterproof recreational audio device is as a comfortable, light weight head band 1 worn by a user. The head band 1 in Fig. 1 can be worn with eye wear such as swimming goggles. The  
20 transducer 2 is located on the inside of the head band 1 to allow contact with the head of the user as shown in Figure 2. Sealed, waterproof wiring (not shown) would be located inside the head band for connecting to a signal source.

One of the major advantages of the waterproof, recreational audio  
25 device is the tuning capability. The skull has many vibratory modes which are likely to be specific to an individual. The unique vibratory pattern of a head is a product of the skull and brain complex geometry, mass and other acoustic properties. The listener compensates for poorly propagating areas of the skull by moving the transducer 2 around the head until optimal

sound quality is obtained. Placement at different locations (frontal, temporal parietal occipital etc.) may dramatically improve listening quality since the head is part of the propagating medium for bone conducted sound on the way to the inner ear.

5           A preferred configuration is to have two or more transducers 2 located at different positions around the head band 1 (e.g., 180° apart). The user could then tune the sound by rotating the head band 1 around the head. Another means for tuning the sound would be to locate the transducers 2 by sliding them around the head band 1 on a slide positioning  
10           guide 3 shown in Figure 3a. Figure 3b shows the use of hooks/snap positioning means 4 connections that would be used to locate the transducers 2 at several positions around the head band 1. Figure 3c shows hook and loop material (e.g., Velcro ®) inside the head band 1 as the means to allow the user to remove and replace the transducers 2 in  
15           preferred positions around the head band 1 for tuning.

          In order to maximize the sound quality of the musical signal, the sound source is amplified and split into three frequency channels. The amplifier unit shown in Figure 4 is powered by a battery 17. A source  
20           signal 18 is received from the sound source and presented to the pre-amps 22 on the driver board 19. The signal source is split into the three frequency channels by the band pass filters 24.

          Amplifiers 23 further enhance the low frequency channel, mid frequency channel, and high frequency channel signals. There are three  
25           attenuators 21, each controls the volume in each of the frequency channels. The listener increases the volume until comfortable in each channel. In this way compensation for the individual differences in sensitivity or preference is obtained. The mid frequency attenuator is preferably set with a maximum level of 90dBa for 8 hours to limit the volume of the mid  
30           range such that individuals near the listener should not be able to hear the sound.

The three channel signal drivers 20 couple the signal to the appropriate transducer 2. The low frequency transducer 2 can be an Audiological Engineering Inc. device or similar device. The mid frequency transducer 2 can be a Radioear Corporation device or similar device, and the high frequency transducer 2 can be a custom designed device from Blatek Inc. further described in Figure 5a, or a similar device. The high frequency sound signal 25, mid frequency sound signal 26 and low frequency sound signal 27 are heard by the user through contact with the transducers 2 to the head of the listener.

The high frequency transducer shown in Figure 5a may be constructed to include of a 1.215 inches dia. X .032 inches thick aluminum disk 12. The aluminum disk 12 is located on top of the .05 inches dia. X .020 inches thick Lead Zirconate Titanate (PZT) disk 13. The PZT (ultrasonic) disk 13 sits within an Aluminum collar 14 that has an outer diameter of 1.25 inches with a wall thickness of .052 mm. The size of the components can vary, which will alter the vibratory response. This may be valuable in some applications. The aluminum collar 14 has a recess machined such that the aluminum disk 12 fits flush along the top of the aluminum collar 14, and the PZT disk 13 vibrates within the cavity created by the aluminum collar 14 and the aluminum disk 12. The signal source is received by the transducer via the wire connected to the insulated solder pin 15 and is grounded by the case ground solder pin 16. The insulation pin can be replaced on one side allowing the connector wire to cross the interior of the transducer.

The intended embodiment of the waterproof recreational audio device/system is to be able to operate in underwater and other high humidity environments. Examples of sub-aquatic, underwater environments include, but are not limited to, recreational and competitive swimming. However, it also includes, but is not limited to, scuba diving or other deeper water environments. Examples of above-water, high

humidity environments include, but are not limited to, jogging, bicycling, hiking or other recreational activities that might expose the device and ear canal to excessive moisture, such as with rain, thereby interfering with normal air-conducted sound.

5           As such, in most applications of the invention, the transducers should be waterproof. Figure 5b shows a cross section of the transducer 2 connected to the head band 1. The transducer 2 preferably is waterproofed by rubberized or polymer coating 6. Water proofing is accomplished by silicone sealing or silicone gaskets may also be used. The main function of  
10           the waterproofing is to protect the transducers from a water or humid environment (e.g., rain), while at the same time allowing the transducers to transmit, via bone conduction, the musical signal to the wearer. As such, any waterproofing that accomplishes this objective might be used in the practice of this invention.

15           Another embodiment of waterproof recreational audio device is to include the sound source as part of the system. The sound source can be an MP3 player, CD player, or other portable musical device. The sound source 7 can be worn on the arm of the listener as shown in Figure 6a and 6b. The sound source is coupled to the head band 1 by a wired connection  
20           8 shown in Figure 6a or by a wireless connection as shown in Figure 6b. The wireless connection would comprise a sound source wireless means 9a that would communicate with the head band wireless means 9b by transmitting and receiving the sound signals as radio, supersonic, or similar transmission means.

25           Although the preferred embodiment is a head band 1, the listener may want to use other types of head gear to position the transducers 2 in contact with the head. Figure 7 shows the transducers 2 are preferably located within a hat 28 that would be worn by the user. The transducers 2 are located inside the hat, next to the head of the listener. Other  
30           embodiments would be to locate the transducers 2 inside a helmet 29, such



as a bike helmet 29 shown in Figure 8 or to locate the transducers 2 on the band of eye wear such as the goggles 30 shown in Figure 9.

Comfort of the user and tuning of the signal are major features for the waterproof recreational audio device. In the event a user wants to position at least one of the transducers 2 on the frontal region of the head, a stabilizing strap 11 is available to hold the head band 1 more securely when a transducer 2 is fixed to the frontal position as shown in Figure 10. The amplification at the three different frequency bands can be independently adjusted providing a personalized audio experience of high fidelity. Unlike air conduction, in which the pathway is the same for all frequencies, the skull unique geometry for each individual requires the device to be tune for maximum satisfaction. Tuning the frequency bands is accomplished by manipulating three attenuators, each of which controls the volume in each of the frequency channels. The listener increases the volume until comfortable in each channel. When all are at a comfortable listening level the user can fine tune the response of all three channels in air and again underwater. In this way compensation for individual differences in sensitivity or preference is obtained. If the listeners wishes the audio image to appear in the center of the head, careful adjustment of the volume is necessary in all three channels

Tuning the volume of the three channels still may not result in the optimal high fidelity experience of sound in the head. Tuning the transducers to the head by positioning may be required. The skull has many vibratory modes which are likely to be specific to an individual. The unique vibratory pattern of a head is a product of the skull and brain complex geometry, mass and other acoustic properties. The listener compensates for poorly propagating areas of the skull by moving the transducers around the head until optimal sound quality is obtained. Placement at different locations (frontal, temporal, parietal, occipital, etc.) will dramatically improve listening quality since the head is part of the

propagating medium for bone conducted sound on the way to the inner ear. Transducer adjustment underwater may also be necessary given that medium's difference in acoustical properties from air.

5       The fidelity of the sound underwater with the device may be enhanced by ear plugging through a masking phenomenon that reduces sound interference of impeded air-conducted sound. This ear plugging can be accomplished with commercially available ear plugs (e.g., silicon); or, at a suitable water depth, there will be normal water loading of the external auditory canal. However, the latter method may not be reliable with  
10       recreational or competitive swimming, and ear plugging may be desired. The user may elect, however, not to use ear plugs, and a quality fidelity sound will still be accomplished with the device. Placing plugs in the ear canal changes the quality of sound by bone conduction. This is termed the occlusion effect (Tonndorf, J. A new concept of bone conduction, *Arch Otol*  
15       87, 49-54, 1968) and it enhances bone conduction listening by increasing the perception of lower frequency sound. The use of plugs or not is the listeners choice. Plugs will require intensity adjustment and possibly transducer placement on the head to create the optimal audio experience.

20       While the invention has been described in terms of a single preferred embodiment, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the appended claims.

**CLAIMS**

~~Having thus described our invention, what we claim as new and  
desire to secure by Letters Patent is as follows:~~

**CLAIMS**

What is claimed is:

- 1        1.    A waterproof recreational audio device for providing musical signals  
2        to a user, comprising:  
3                at least one transducer, such that said transducer enables music to  
4        be heard by said user via transcutaneous bone conduction;  
5                a means for said at least one transducer to be in vibratory contact  
6        with the head of said user; and  
7                means for waterproofing said at least one transducer.
  
- 1        2.    The waterproof recreational audio device according to claim 1,  
2        wherein said at least one transducer includes a plurality of transducers.
  
- 1        3.    The waterproof recreational audio device according to claim 2,  
2        wherein said plurality of transducers is arranged in an array.
  
- 1        4.    The waterproof recreational audio device according to claim 2,  
2        wherein the musical frequency range is split into three frequency channels.
  
- 1        5.    The waterproof recreational audio device according to claim 4,  
2        wherein said three frequency channels consist of:  
3                a low frequency range,  
4                a mid frequency range, and  
5                a high frequency range.

1       6.   The waterproof recreational audio device according to claim 3,  
2       wherein at least one of said transducers in said array is an ultrasonic  
3       transducer.

1       7.   The waterproof recreational audio device according to claim 3,  
2       wherein at least one of said transducers in said array is a vibrotactile  
3       transducer.

1       8.   The waterproof recreational audio device of claim 1, wherein said  
2       audio device includes at least one amplifier.

1       9.   The waterproof recreational audio device according to claim 1,  
2       wherein at least one of said transducers is positionable at the front of the  
3       head of said user.

1       10.   The waterproof recreational audio device according to claim 1,  
2       wherein at least one of said transducers in said array is positionable at the  
3       back of the head of said user.

1       11.   The waterproof recreational audio device according to claim 1,  
2       wherein said transducer is associated with a band that encircles the head of  
3       a user.

1       12.   The waterproof recreational audio device according to claim 1,  
2       wherein said transducer is associated with a hat that is worn on the head of  
3       said user.

1       13.   The waterproof recreational audio device according to claim 1,  
2       wherein said transducer is associated with a helmet that is worn on the

3 head of said user.

1 14. The waterproof recreational audio device according to claim 1,  
2 wherein said transducer is associated with a band of recreational eye wear  
3 selected from the group consisting of swim goggles, ski goggles, snorkel  
4 mask, and sun glasses.

1 15. The waterproof recreational audio device according to claim 5,  
2 wherein said low frequency range volume is adjustable.

1 16. The waterproof recreational audio device according to claim 5,  
2 wherein said mid frequency range volume is adjustable.

1 17. The waterproof recreational audio device according to claim 5,  
2 wherein said high frequency range volume is adjustable

1 18. The waterproof recreational audio device according to claim 1,  
2 wherein said mid frequency range has a fixed maximum signal level of 90  
3 dBa for 8 hours.

1 19. The waterproof recreational audio device of claim 1, wherein said  
2 waterproof recreational audio device transmits a musical signal of a high  
3 fidelity frequency response across a broad frequency range where there is:  
4 a low frequency response is in the range of 40 - 1000 Hz  
5 a mid frequency response is in the range of 250 - 6000 Hz, and  
6 a high frequency response is in the range of 5000 - 20,000 Hz.

1 20. The waterproof recreational audio device of claim 19, wherein said  
2 at least one transducer includes an ultrasonic transducer.

1       21.   The waterproof recreational audio device of claim 19, wherein said  
2       at least one transducer includes a vibrotactile transducer.

1       22.   The waterproof recreational audio device of claim 19, wherein said  
2       waterproof recreational audio device includes an adjusting capability for  
3       the mid range frequency response, such that:

4               said mid frequency range volume can be adjusted to allow  
5       environmental noise to be heard by the user,

6               said mid frequency range has a fixed maximum level to minimize  
7       nuisance noise for individuals near said waterproof recreational audio  
8       device, and

9               said mid range has a fixed maximum level to restrict harmful dB  
10      noise levels for user.

1       23.   The waterproof recreational audio device of claim 19, wherein a  
2       volume of said low frequency range is adjustable.

1       24.   The waterproof recreational audio device of claim 19, wherein a  
2       volume of said mid frequency range is adjustable.

1       25.   The waterproof recreational audio device of claim 19, wherein a  
2       volume of said high frequency range is adjustable.

1       26.   The waterproof recreational audio device of claim 19, wherein said  
2       mid frequency range has a fixed maximum signal level of 90 dBa for 8  
3       hours.

1       27.   The waterproof recreational audio device of claim 1 further  
2       comprising a sound source in communication with said at least one  
3       transducer, said sound source generating a music signal which is received

4 by said at least one transducer.

1 28. The waterproof recreation audio device of claim 27 wherein said  
2 communication between said sound source and said at least one transducer  
3 is via a wired connection.

1 29. The waterproof recreation audio device of claim 27 wherein said  
2 communication between said sound source and said at least one transducer  
3 is via a wireless connection.

1 30. The waterproof recreation audio device of claim 27 wherein said  
2 sound source is affixed to said means for said at least one transducer to be  
3 in contact with the head of said user.

1 31. The waterproof recreation audio device of claim 27 wherein said  
2 sound source is selected from the group consisting of MP3 player, tape  
3 player, radio, audio transceiver, and disc player.

1 32. A recreational audio device, comprising:  
2 at least one transducer which enables music to be heard by a user  
3 via transcutaneous bone conduction; and  
4 a support which supports said at least one transducer in contact  
5 with a head of a user at a plurality of locations around the head of said  
6 user.

1 33. The recreational audio device according to claim 32 wherein said at  
2 least one transducer includes a plurality of transducers.

1 34. The recreational audio device according to claim 32 wherein said at  
2 least one transducer can be removed from said support and re-positioned at

3 at least one different location on said support.

1 35. The recreational audio device according to claim 32 wherein said at  
2 least one transducer can slide to different locations on said support.

1 36. The recreational audio device according to claim 32 wherein said  
2 support can be oriented at multiple orientations relative to a head of a user.

1 37. The recreational audio device of claim 36 wherein said support is a  
2 head band.

1 38. The recreational audio device of claim 32 further comprising  
2 waterproofing for said at least one transducer.

1 39. The recreational audio device of claim 32 further comprising a sound  
2 source for conveying musical signals to said at least one transducer.

1 40. A method for a user to listen to music via transcutaneous bone  
2 conduction, comprising the steps of:  
3 supplying musical signals from a source to at least one transducer  
4 capable of transcutaneous bone conduction;  
5 contacting a user's head with said at least one transducer; and  
6 transmitting by transcutaneous bone conduction said musical signal  
7 to the user.

1 41. The method recited in claim 40, further comprising a step of tuning  
2 musical sound heard by a user.

1 42. The method of claim 41 wherein said step of tuning comprises  
2 changing point of contact of at least one transducer on a user's head.



1       43. The method of claim 42 wherein changing is accomplished by  
2       repositioning a support which supports said at least one transducer on said  
3       user's head.

1       44. The method of claim 42 wherein changing is accomplished by  
2       repositioning said at least one transducer on a support which supports said  
3       at least one transducer.

1       45. The method of claim 42 wherein changing is accomplished by sliding  
2       said at least one transducer to a different location on a support which  
3       supports said at least one transducer.

1       46. The method of claim 40 comprising adjusting volume of at least one a  
2       high, mid, or low frequency transmitted via transcutaneous bone  
3       conduction via said at least one transducer.

1       47. The method of claim 40 further comprising limiting a mid frequency  
2       range has a fixed maximum signal level of 90 dBa for 8 hours.

**~~ABSTRACT OF THE DISCLOSURE~~****ABSTRACT**

A waterproof recreational audio device and method that transmits sound via transcutaneous bone conduction provides high fidelity musical signals to a user. The device can be worn on the head of a user and integrated into various types of headgear. The device is tunable for sound quality and comfort by adjusting and moving the sound transmitting transducers around the head of the user. The present invention ~~uses commercially available~~ preferably uses transducers to produce sounds in the low, mid and high frequency ranges. A sound source for the musical signal can also be provided as part of the waterproof recreational audio device. Controls enable the user to select volume levels for the high, mid and low frequency ranges, while a volume limiter restricts the mid range to a preset maximum volume level to allow external ambient sounds to be heard via the ear canal and protects the hearing of the user.